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(54) **Hydraulic operated reamer.**

(57) Hydraulic operated underreamer (1) for enlargement of boreholes. The underreamer comprises a cylindrical body which is arranged for connection to a rotating drill string. The reamer (1) has an outer movable cylinder (2) which is stretching out in the whole length of the reamer for protection of the inner parts. The reamer has cutter support arms (5) which in operative state are extending out from the body and in closed state are completely retracted within the cylindrical body. Cutters are mounted on the support arms (5), which are axially movable. The outer cylinders (2) have openings for passage of the support arms.

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Description

HYDRAULIC OPERATED REAMER

This invention concerns a hydraulic operated underreamer.

This is a tool which is used to enlarge boreholes. Such tools can be used in drilling for oil, gas and water and for mining, drilling of construction holes and wells and also in the formation of shotholes for blasting. An underreamer has two operative states, namely a closed or collapsed state where the diameter of the tool is sufficiently small to allow movement of the reamer in the narrowest part of the borehole, and a second opened or partly expanded state, where one or more tool holders (arms) with cutters on the ends pivot out from the body of the tool. In this position the borehole is enlarged as the tool is rotated and lowered.

A drilling type underreamer usually is used in conjunction with a drill bit below the underreamer. The drill bit forms the hole to be underreamed at the same time as the underreamer enlarges the hole formed by the bit. Circulation of drilling fluid must be provided to the drilling bit to remove cuttings during the drilling operation.

Underreamers of this type usually have hinged arms (tool holders). These have a tendency to break during the drilling operation and must be fished up from the borehole. The tool has pockets in which the arms are situated in the closed state. These pockets have a tendency to be filled with waste material from the drilling operation, which makes the collapsing of the arms difficult. This leads to the danger that the underreamer may be hooked in the borehole, causing problems in the withdrawal of the tool. The costs also can be considerable. In addition, this type of reamer is very large and heavy and has a complicated structure and is composed of many parts. Such a type of underreamer is for example described in U.S. Patent No. 4282941.

The object of the invention is to produce an underreamer which is reliable, stable and which has less risk of being stuck in the borehole. Further, it is important that it has a simple construction and is of moderate size.

An underreamer in accordance with the invention comprises a cylindrical body arranged for coupling to a rotating drilling pipe and cutting tools installed on support arms which are arranged to be moved from an inoperative to an operative position by hydraulic pressure characterised in that the reamer (1) has an outer movable cylinder (2) for protection of the inner parts and in that the cutter support arms (15) are axially movable.

An important feature of the underreamer is that is has an outer cylinder extending the whole length of the reamer which protects all movable parts against earth, stones etc. The cylinder may be associated with a piston to constitute a slide valve. The cylinder will then restrict the length of stroke of the piston and helps the self-closing of the reamer. The piston is preferably fixed to a pipe of the same dimension as the drilling pipe. The lower part of the piston may then form the upper part of a claw-coupling for transfer of torsional forces. The arms may be fixed to the piston through connecting bars.

The lower part of the claw coupling preferably ends in a section with triangular cross-action and with guide facings (grooves) for the arms.

It is important for the stability of the underreamer that the cutter support arms can be moved in an axial direction. By lowering of the reamer into the borehole the support arms will be retracted within the cylinder. When mud is pumped down, the support arms with the cutters will be pressed out to the required diameter. The reamer preferably has a locking device which prevents the support arms from being pressed out during the lowering of the reamer. It also preferably has a locking mechanism for locking of the arms in the operative position. Also important for the stability of the reamer is that it is filled with mud and that a negative cutting angle is used.

A preferred embodiment of a reamer in accordance with the invention will now be further described by way of example with reference to the accompanying drawings in which:-

Figure 1 shows the reamer with the arms in expanded state,

Figure 2A is a section along the line A-A in Figure 1,

Figure 2B is a cross-section view taken along the line B-B in Figure 2A,

Figure 2C is a cross-section view taken along the line C-C in Figure 2A,

Figure 2D is a cross-section view taken along the line D-D in Figure 2A,

Figure 3A is the upper part of the reamer in locked position (the support arms retracted),

Figure 3B is the upper part of the reamer in open state.

The underreamer 1 consists of four main parts, an outer cylinder 2, piston 3, supporting body 4 for the arms and arms 5. In Figures 1 and 2 the reamer is shown with the arms pressed out. The reamer has an outer cylinder 2 extending the whole length of the reamer. The cylinder forms a cover for the reamer and protects the movable parts against drill cuttings.

In the figures the reamer is shown with two concentrically located cylinders 2, 6 where the inner cylinder 6 has grooves 7 which together with the outer cylinder form channels for transportation of mud inside the cover. Because the cylinder is double the channels for mud may easily be coated with ceramic resistant material. Alternatively the cylinder can be single and have bore holes for passage of mud. In the lower part of the cylinder there are arranged cavities/pockets 8 where the support arms 5 passes through. Mud also flows from the cavities/pockets. During the reaming operation there is over pressure inside the cylinder. The upper part of the cylinder forms a slide valve together with the piston 3. The cylinder and the lower part of the claw coupling, limits the complete stroke and thereby the extension of the cutter support arms 5.

A smaller deflection of the drilling arms can be obtained by several guide tracks cut out in the triangular part of the reamer. Besides, the cylinder gives weight to the self-closing. The cylinder can be moved in a vertical direction under the influence of the drilling fluid.

The piston 3 is connected to a pipe 9 of the same dimension and threads 10 as the drilling pipe. The piston 3 has radial channels 12 which end in openings 13 in the top of the piston for inlet of drilling fluid. The number of channels is determined by flow, pressure loss etc. The lower part of the piston is formed like a claw coupling 15 for transference of torsional forces. In the figures the coupling is shown with three "claws", the same number as the number of cutters. This number can be varied. Each coupling claw is equipped with groove 16 and pin 17 for transference of sliding forces through connecting bars 18 to the cutter support arms 5. The grooves 16 in the claws of the piston are parallel to the faces of the triangular profile.

The piston is equipped with a locking mechanism which prevents the cutter support arms from kicking out if the tool should be subject to stroke or thrust whilst being lowered into the bore hole. The locking mechanism as shown in the figures consists of a locking piston 11 which is influenced by the pressure of the drilling fluid. The locking piston 11 is arranged in the centre of the piston 3 of the reamer. Further the mechanism includes bolts 19 with guiding pins 20. The mechanism is supported by a spring 21. In the locked position the locking piston closes the passage for drilling fluid to the channels 12 (Figure 3).

In the operative position the cutter support arms 5 can be locked by a tap 22 arranged at the lower part of the connecting bars and which engage in a groove 23.

The upper part of the supporting body 4 for the cutter support arms has a circular cross section and forms the lower part 24 of the claw coupling 15 for the transference of torsional forces. The middle part of the supporting body has, in this case, a triangular profile 25 because the reamer as shown is equipped with three cutters. At each side of and at a certain angle to the triangular profile a groove 26 for the cutter support arms 5 is milled. The grooves are arranged in such a way that one can choose between a positive and negative cutting angle. Both T-grooves as shown in the figures and dovetailed grooves can be used. This construction gives maximum support and minimum moments to the cutter support arms. The triangular profile can eventually be equipped with a lower circular part. If more support arms are required, the triangular profile 25 can be replaced with a profile with more side faces.

The cutter support arms 5 can be moved in T-grooves as shown in the figures, or dovetail grooves. The support arms have groove 27 and pin 28 for fixing of connecting bars 18. More than the half of the total length of the cutter support arms will be inside the supporting body which gives good support during drilling/working. The cutting tool is made with reversing cutters where the cutting part of the tool consist of a plate which is fixed to the end of the cutter support arm in a groove. It is fixed with screws. The tool can be equipped with diamonds, hard metal or ceramic cutters.

The lower part of the cylinder can be formed for connection to a drill bit. In Figure 1 the underreamer is shown with a lower conical part 30 fixed both to the cylinder and triangular profile and with threads 31 for fastening to the drilling pipe. In the lower part there are channels 32 for passage of drilling mud from the underreamer to the drill bit.

When the reamer is hanging in the drilling pipe, the piston 3 and end cover of the cylinder 2 will drag on to each other as shown in Figures 3A and 3B. The cutter support arms 5 will be retracted and be within the construction.

When drilling mud is pumped through the pipe 9, the mud will force the locking piston 11 down and the bolts 19 will be forced out of grooves in the cylinder wall. This opens for passage of drilling mud through the channels 12. The mud will pour out through the openings 13 and lift the cylinder 2 with lower claw coupling/triangular profile 24, 25 until the two parts 15, 24 of the claw coupling is in complete contact with each other.

Because the cutter support arms 5 is connected to the piston 3 through connecting bars 18 the support arms will be pressed out. The locking tap 22 on teh connecting bars will slide into the groove 23 and lock the support arms. When the underreamer is in operative position there will be contact between the space 33 and the channels 7 in the cylinder wall. Drilling mud then will pour through the channels 7 and wash the cutter support arms. A part of the drilling mud will pass through to a drill bit via channels 32.

When the underreamer is to be moved out of the bore hole the support of drilling mud is stopped. The drilling mud will pour out through channels and leak holes including extra leak hole 34, for emptying of the space 33. When the drill bit is drawn up, the cylinder will slide down again to the top of the piston and the cutter support arms will be retracted into the cylinder body. The locking cylinder will close for passage of drilling mud into the reamer.

A reamer filled with drilling mud combined with the use of negative cutting angle, creates conditions which will counteract vibrations and make stable cutting conditions. The use of axial movement of the cutter support arms promotes the stability.

The operator would be able to notice if the cutter support arms are in open state by register if the drilling mud is circulating.

A construction in accordance with the invention provides a reamer with good stability. Of importance for good stability is the use of axial movement cutter support arms and that the reamer is used with negative cutting angle. The construction avoids the reamer being stuck in the bore hole when it is pulled up. It is easy to change the cutters and put in spare parts. The underreamer has a small height, low weight and consists of less parts than reamers which are in use today. All movable parts are besides protected from stones and stand by the outer

cylinder and over pressure inside the cylinder.

Claims

1. A hydraulic operated underreamer comprising a cylindrical body arranged for coupling to a rotating drilling pipe and cutting tools installed on support arms which are arranged to be moved from an inoperative to an operative position by hydraulic pressure characterised in that the reamer (1) has an outer movable cylinder (2) for protection of the inner parts and in that the cutter support arms (5) are axially movable.

2. An underreamer according to claim 1, characterised in that the cylinder (2) extends the full length of the reamer and has openings (8) for passage of the cutter support arms (5) if over pressure can be established.

3. An underreamer according to claim 1 or 2 characterised in that the cutter support arms (5) are arranged to be completely surrounded by the outer cylinder (2) in the inoperative state.

4. An underreamer according to any of the preceding claims characterised in that the cutter support arms (5) are arranged to be moved in angular grooves (26) with negative or positive cutting angle.

5. An underreamer according to claim 5, characterised in that the grooves are formed as T-grooves or dovetailed grooves.

6. An underreamer according to any of the preceding claims characterised in that the reamer has three cutter support arms (5).

7. An underreamer according to any of the preceding claims characterised in that the cutter support arms have reversing cutters (29).

8. An underreamer according to any of the preceding claims characterised in that the reamer (1) has a piston (3) fixed to a rod (9) which is arranged to be coupled to the drilling pipe, and where the outer cylinder (2) restricts the total stroke length for the piston, and where the lower part of the piston forms the upper part of a claw coupling (15) and where the support arms (5) via connecting bars (18) are fixed to the piston (3).

9. An underreamer according to any of the preceding claims characterised in that the reamer has a lower claw coupling (24) arranged to be in complete contact with an upper claw coupling (15) when the reamer is working, and where the lower part of the coupling is in the shape of a triangular profile (4) where each side face has milled guiding grooves (26) for the cutter support arms.

10. An underreamer according to any of the preceding claims characterised in that the reamer is equipped with a locking piston (11) with bolts (19) and guide pins (20) and has a locking mechanism (23, 29) for locking of the cutter support arms (5) in operative state.

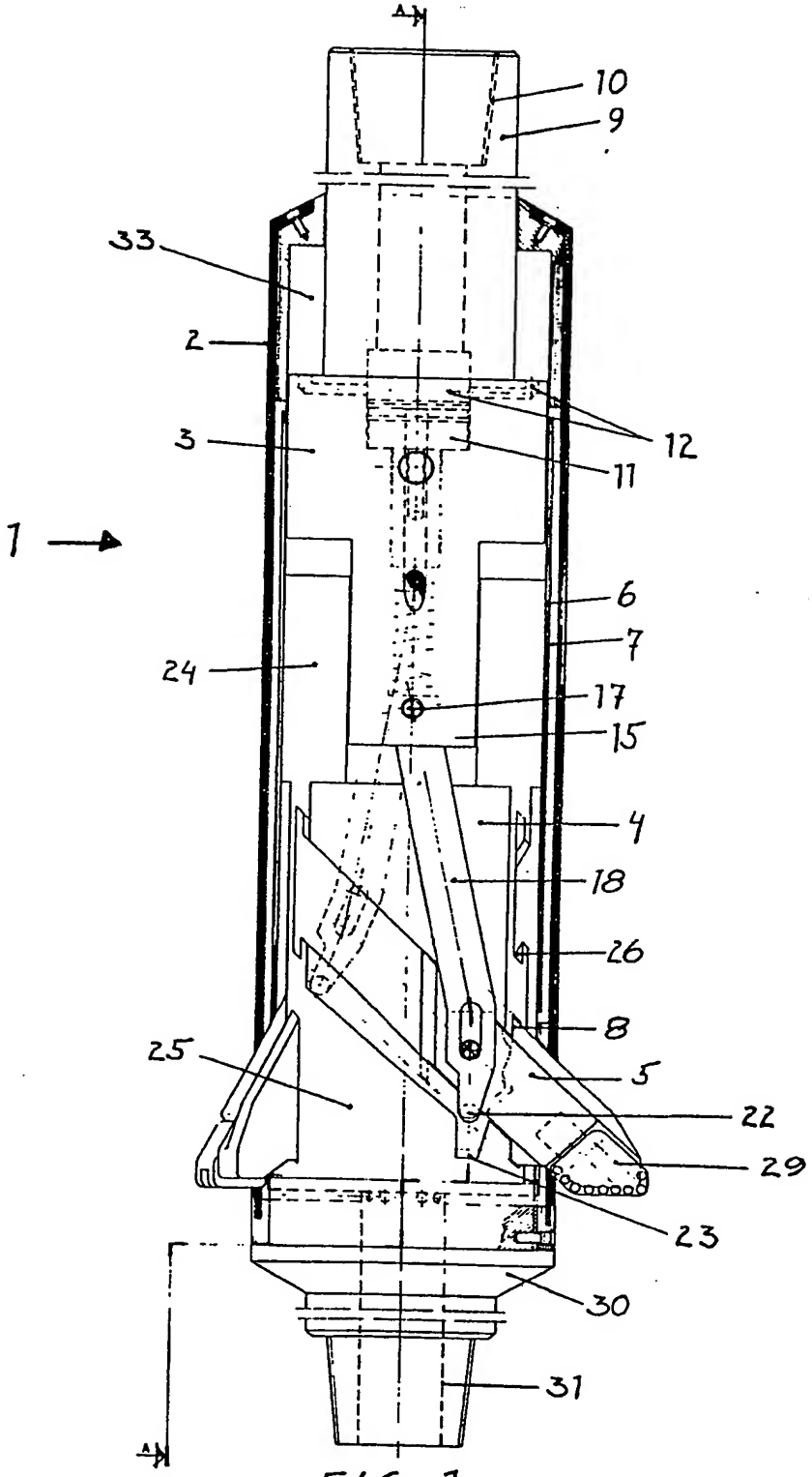

FIG. 1

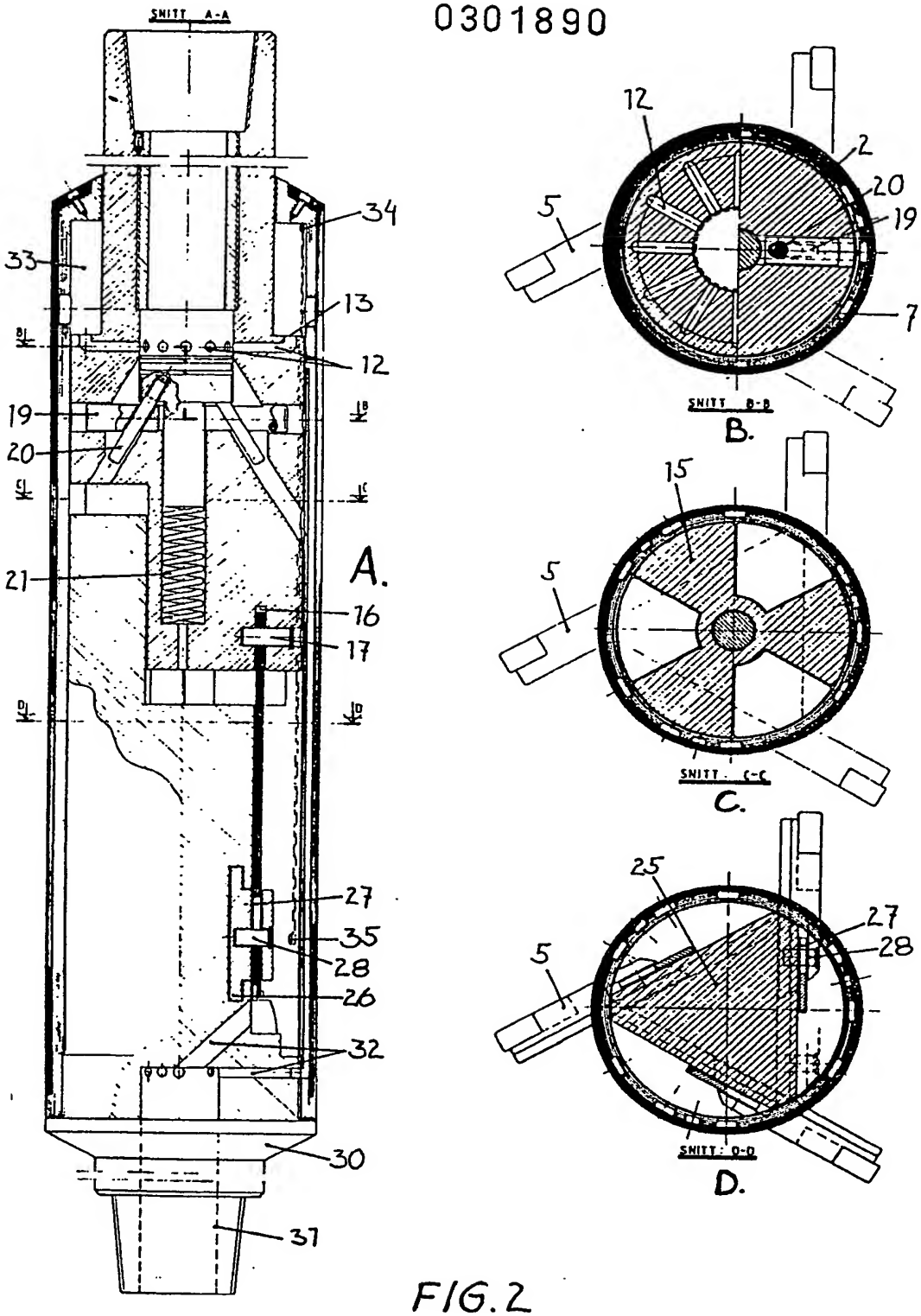
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FIG. 2

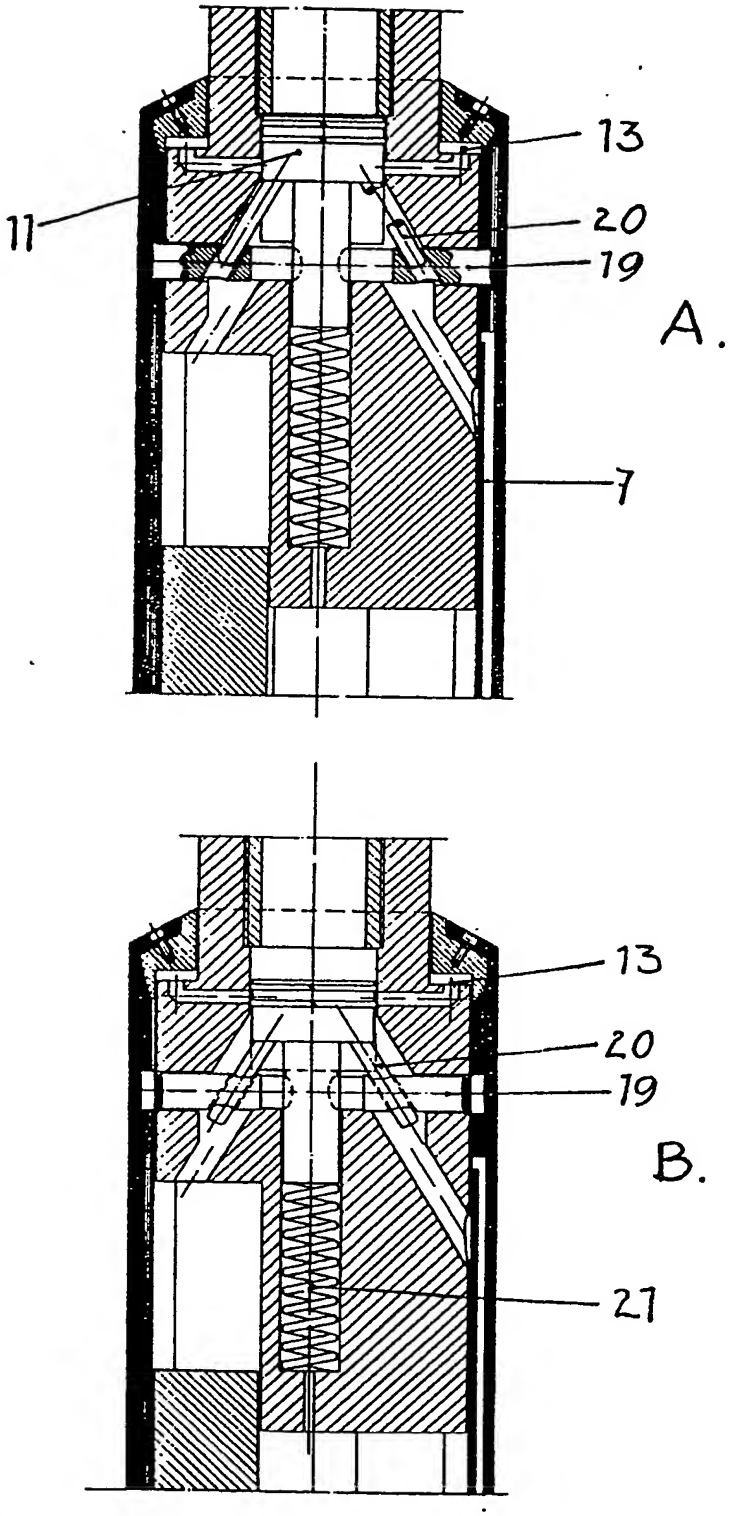

FIG. 3